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Current practice of preparing morphine infusions for nurse/patient controlled analgesia in a UK paediatric hospital: healthcare professionals' views and experiences

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Abstract

Objective

To explore the views and experiences of healthcare professionals (HCPs) regarding the preparation of morphine infusions for nurse/patient controlled analgesia (N/PCA).

Methods

Three focus groups were conducted with HCPs (anaesthetists, nurses in theatres and wards) at one UK children's hospital. Focus groups were transcribed verbatim and content analysis was used to identify themes.

Results

A variety of approaches are used to prepare morphine infusions. A lack of appreciation of the excess volume present in morphine ampoules that nominally contain 1 or 2 mL was identified. Other sources of error were miscalculation, complexity of the multi-step procedure, distractions and time pressure. Participants suggested that 'ready-to-use' prefilled syringes and pre-programmed syringe pumps would improve practice and minimise the risk of error.

Conclusion

Risks associated with the preparation of infusions for paediatric N/PCA, in particular non-appreciation of the overage (excess volume) in morphine ampoules, raises concerns about the accuracy of current practices.

What is already known on this subject

- It is well recognised that preparing intravenous infusions for children is a complex process which poses serious risks, especially when preparing potent medicines.
- Currently there is no standard preparation method that healthcare professionals can follow when preparing morphine intravenous infusions for nurse/patient controlled analgesia for children.

What this study adds

- This study found deficiencies in HCPs knowledge of how to perform accurate infusion preparation. Amongst other factors, we identified an unexpected lack of appreciation of the 'overage' (excess volume) present in morphine ampoules. New, safer procedures are recommended to improve the current practice of preparing intravenous morphine infusions for children, for example programmable infusion pumps in tandem with 'ready-to-use' preparations of standardised concentrations.

INTRODUCTION

The process of preparing and administering an intravenous drug is complex with multiple error-prone steps, which may lead to mistakes that have serious adverse outcomes for patient.[1]

Unlike adult practice, where most patients receive standard concentration drug infusions, nurse- and/or patient-controlled analgesia (N/PCA) for children is prepared as an 'individually made product', i.e. prepared for each patient based on their age or weight. This is done by using the "rule of 6" formula [2] to calculate the infusion concentrations prescribed in micrograms per kilogram per minute. This formula is described as: 6 x patient's weight (kg) equals the amount of drug in milligrams that should be added to 100 mL of solution, when administered at 1 mL/h to give an infusion rate of 1 microgram/kg/min.[2]

The aim of this study was to explore views and experiences of healthcare professionals (HCPs) on the current practice of preparing morphine infusion for N/PCA use in children and identify any problems they encountered during preparation and administration.

METHODS

Three focus groups were conducted during 2014 with HCPs from three clinical areas at the Evelina London Children's Hospital (ELCH), paediatric ward nurses, operating theatre anaesthetists, and recovery nurses. Focus groups were organised to discuss with HCPs their current practice in preparing morphine infusion for N/PCA, their views and experiences, and to explore any problems they encountered during preparation and administration.

Focus group topic guide was developed by the research team, based on local hospital policy and published literature [1,3-4], covering aspects of current practice in preparing and administering morphine N/PCA. These included; calculation of drug dose, mixing of morphine IV injection with diluent, programming the infusion pump, factors contributing to

occurrence of morphine N/PCA medication errors, and possible solutions to minimise such errors. This guide was used by the moderator to guide the discussion, with all three focus groups undertaken using the same topic guide.

The focus groups were conducted by two members of the research team (CW-moderator, ANR–assistant moderator). Focus groups were audio-recorded and recordings transcribed verbatim (ANR) and validated (CW).

Data Analysis

An anonymised transcript of each focus group was uploaded to QSR NVivo (version 10) software for coding and categorisation to identify themes. Qualitative content analysis was used with three main themes being set *a priori* and supplemented by emergent subthemes identified during analysis.[5-6] Coding frames were prepared and framework analysis created by ANR and checked by CW.

RESULTS

Three separate focus groups (FG) were conducted with participants recruited from the three different clinical areas; 1) FG with theatres' anaesthetists (n=5), 2) FG with ward nurses (n=4), 3) FG with recovery nurses (n=5). Each FG was 45-60 minutes duration. All except one of the participants were female (n=13).

Three main themes were identified: 1) views on the current practice of preparing morphine infusions for N/PCA use, 2) problems and factors contributing to errors in current practice, 3) suggestions to improve current practice and minimise errors. These themes and sub-themes are summarised in table 1 with illustrative quotes from the focus groups. The individualised syringe preparation at ward and/or theatre level was not standardised in terms of mixing drug with diluent, as described by participants. This including the challenge of using different syringe sizes in one preparation, (table 1).

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157 **Table 1 Summary of topic themes and subthemes identified from the focus groups**

Theme	Subthemes	Example quotes
The current NCA/PCA preparation process	Paper work; prescription, calculation sheet Calculation checking Mixing drug with diluent Programming the pump The double checking process Labelling	*"There are two pieces of paper work to do this. There is the prescription which goes on the "as required" section of the drug chart. That's presented as a sticker, so you need to check whether it is the right sticker, and then there is the calculations sheet which also comprises the administration record. So that has a number of calculations to do based on patient's weight. Once those calculations have been done, then you need to obtain the drugs, the diluent, and then draw it up, and then purge the line, place it in the syringe driver, and programme the syringe driver, then attach it to the patient."* (paediatric anaesthetist-1)
	Changing syringes	*"our responsibility…we have to change the syringe….but we can't change any information, on any programme."* (ward nurse-1)
Factors contributing to errors in current practice	Time pressure/busy environment, multitasking Calculations	*"We get distracted. There is always other things going on and you get distracted from what you are doing, and there is not always somebody who could actually sit down with you and reliably check all your calculations, so you can get someone to check it on the pump sure, but not necessary, that what I find anyway."* (paediatric anaesthetist-2)
	Wrong labelling Wrong protocol used Wrong programme on pump	*"We have a variety of errors. It can be; no patient's identification on the label on the syringe; no signature on the syringe; no dose on the syringe; the wrong sticker be stuck on the chart; occasionally the wrong protocol has been as well, and occasionally sometimes, the programme doesn't correlate with the protocol. For instance, the protocol may says the background, the programme doesn't."* (recovery nurse-1)
	Drug ampoule overage	*"So for example if you need 26 mg in 50 mL, I will draw up two 10s and then I will draw 10 in 10 and take out 6. So that how I do it."* (ODP[†]/recovery nurse-4)
	Mixed system used in PICU*	*"Because in the intensive care we have the pain sedation while patients are intubated, we have pre-prepared morphine syringes. That's what we generally use. Only when we are going to send a child to ward or they come from theatre and then they come with NCA or PCA…"* (ward nurse-2)
	Look-alike error	*"Some drugs draw up to 100 mL bag, and hardly any clear solution come in 100 mL bag, and one of them is metronidazole, so on one occasion the PCA was prepared in metronidazole rather than a saline."* (paediatric anaesthetist-3)
	Use of different syringe sizes in one preparation	*"I think there is a challenge which I am sure it should have been shown up in the observations, and that is the different syringes, 1 mL, 2 mL, 2.5 mL syringes where you have got to draw up, say, 1.66 mL, do you use a 1 mL-syringe and then 2.5 mL -syringe to do the 1 mL, then 0.66, or do you use the 2.5 mL-syringes. So there will be inconsistency."* (ward nurse-3)

	Delays in obtaining drugs/key/paperwork	*"Potential for delay and error is if more than one person is involved, like if a trainee would start of the whole process, then we take over or vice versa, but that happened to me when I started the same thing then the trainee took over and then there was an error that I had to correct it later, but it could've been potentially dangerous."* (paediatric anaesthetist-1)
	Not purging the pump	*"There is one problem that I saw many trainees having. They don't engage the plunger on the syringe pump, and on very small baby sometimes it takes half a mL or whole mL before it actually starts dripping at the other end, which means that may be 10-15 minutes will pass before they actually get any analgesia. Maybe half an hour if it is small baby."* (paediatric anaesthetist-4)
	Out-of-hours and knowledge of people with the process	*"Out of hours perhaps is more problematic because you don't have the pain nurse support… particular during changeover of the doctors, sometimes, information is not related to who they could contact if they have problem."* (recovery nurse-2)
Improvements in practice and suggestions to minimise errors	Use PFS[††]	*"Pre-filled syringes, all the way…Because they will be already made-up, just select the syringe that you want and attach it, there is no faffing around with CD* [controlled drug] *book checking out the CD, drawing it all up. I mean takes quite time to draw up 49 mL of saline."* (ward nurse-4)
	Separate storage for look-alike drugs and diluents	
	Computer programme for calculations	*"Could be integrated with EPR* [electronic patient record] *quite easily…definitely would be part of the electronic prescribing once that's available"* (paediatric anaesthetist-1)
	Preparation of N/PCA by recovery nurses	*"The only thing that comes to me is something that I've done before, but not in paediatric setting in adult setting, where the recovery staff set up the pumps. So it is bit more of a controlled area…I think you can get that where two people step out and do the pump and do the drawing up and then take it into theatre, but then again about you going to connecting up something you don't know about it."* (recovery nurse-3)

*PFS of morphine standard concentration for continuous infusion and individually prepared concentration for N/PCA; [†]ODP = Operating department practitioner;
[††]PFS = pre-filled syringe

Lack of appreciation by the HCPs of the volume overage in morphine ampoules was an emergent theme identified during the focus groups. This was primarily an issue for anaesthetists in theatres (Box 1), although some nurses also explained they were not aware that a measured volume must be withdrawn to accurately extract 10 mg morphine from a 10 mg in 1 mL morphine ampoule.

Box 1: Excerpt of the transcript of the anaesthetists' focus group referring to the actual volume of solution contained in a morphine ampoule.

Anaesthetist 1: *"The ampoules are overfilled. It's supposed to be 10 mg/mL, but there is more than 1 mL in every ampoule."*

Anaesthetist 2: *"Say I've got a 27 kg* [weight] *child, and you have to put 27 mg in* [50 mL]*. I'll always put the 20 mg, all of the ampoules in* [whole content of 2 ampoules in 50 mL-syringe]*, as I opposed to drawing it up in a syringe* [separate syringe with different size] *I will be losing some and I want to make sure that I get what I think in my head is 27* [mg]*. So the first 2* [ampoules] *will get the full ampoule* [whole content of the 2 ampoules] *and only* [for] *the last 7 mg that I will draw* [them] *up in a 1 mL syringe."*

Anaesthetist 3: *"Yeah, only in round numbers. Like if 30 kg* [child's weight]*, you have 3 ampoules, you put them all* [whole content of the 3 ampoules] *into the diluent. But if it's 15 kg* [weight] *baby, you have to have two syringes* [2 syringes capacities; one to draw up 1 mL (containing 10 mg) and another to draw up 0.5 mL (containing 5 mg)]*."*

Participants identified several factors that contributed to the occurrence of errors when preparing morphine infusion for N/PCA such as wrong calculations, wrong label, and using the wrong protocol, look-alike drugs, inaccurate volume measurement, distractions/busy environment, delays due to obtaining morphine ampoules, multi-tasking, and time pressures (Table 1). This is illustrated in the example below.

"I think time could add on in any contributing factor, as time pressures. Basically links to multi-tasking, but time pressure with something, you are doing something,

you want the child to have pain relief and you want to get on and do it as quickly as possible and I guess all those small things will add on and cause an error; which is a simple calculation of 2, zero, and 1 and 2" (paediatric anaesthetist).

Possible measures to improve practice and minimise errors were identified by participants such as use of 'ready-to-use' prefilled syringes, use of a computer programme for calculations and use of separate storage for look-alike drugs (Table 1).

DISCUSSION

This study provides a valuable insight into everyday practice of administering N/PCA for children. During the focus groups, participants identified several factors that might contribute to possible medication errors, such as complex calculation, distractions, busy environment, time pressure, and mixed systems, where prefilled syringe of standard concentration infusion and individually prepared infusions are both used in the same clinical area. Similar factors have been reported in previous studies that investigated causes of IV drug preparation errors.[7-9]

During the focus group HCPs, predominately the anaesthetists, explained their confusion about the volume of morphine solution presented in an ampoule, and reported their practice of withdrawing the entire ampoule contents including the volume overage during their preparation of morphine infusions. It is possible to draw 1.1 mL out of a 10 mg in 1 mL ampoule, which would mean that 11 mg are taken, giving a +10% error. This was consistent with positive deviations in the concentration of morphine infusions prepared by HCPs (unpublished data by our team).

The participants in the focus groups identified various strategies to reduce the number of manipulations required in morphine infusion preparation to minimise the occurrence of errors. Many of these have been suggested previously. The use of prepared standardised infusion was one strategy.[8, 10] A study in children identified that the number of reported

errors associated with continuous medication infusions was reduced by 73% following implementation of standard drug concentration solutions administered using advanced safety pumps with inbuilt ‘drug libraries’ and default settings to facilitate selection of correct medication and dose.[11]

This study identified the need to improve current practice. Potential solutions include standardisation of morphine concentrations for N/PCA use and/or bulk manufacture of ‘ready-to-use’ infusions in a quality-controlled environment, interventions to increase knowledge on the use of correct syringe size and overage in ampoules.

The study was conducted in a single paediatric NHS hospital and reflects the current practice there. The results may not be generalisable to all NHS paediatric hospitals, however, staff turnover between hospitals is large and thus there is no reason to believe that knowledge or practice elsewhere is significantly different. Not all staff who prepared morphine N/PCA infusions at this hospital participated in the focus groups and thus the full picture of practice cannot be guaranteed.

CONCLUSIONS

There is little standardisation of the techniques used to prepare N/PCA infusions for children, which raises concerns about the accuracy of current preparation practices. A particular issue was the lack of appreciation of the overage (excess volume) in morphine ampoules. The flaws identified in the current process should be addressed and a number of potential solutions were recommended.

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Conflict of interest

ANR was funded by the Health Foundation. Other authors declared no financial interests.

Ethical Approval

This study was approved by the Research and Development (R&D) department at Guy's and St Thomas' NHS Foundation Trust (GSTT) and categorised as a non-Ethics study. The local NHS Research Ethics Committee confirmed that NHS ethics approval was not required.

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